may encounter increased temperatures when in direct sunlight. This increased temperature may contribute to an increased heat load beyond the design parameters of the satellite which, in turn, may contribute to the failure of one or more systems on the satellite. Conversely, extreme cold conditions are also encountered in space which will decrease the temperature of the spacecraft below the design parameters. This condition may also affect the many systems on the spacecraft. To combat wide variations in temperatures on the surface of the spacecraft, prior art systems used louvers to regulate the temperature of the spacecraft. The louvers increase or decrease the surface area of the spacecraft in order to either store or dissipate heat, depending on the particular environment encountered by the spacecraft. However, louvers are mechanical systems which have a tendency to fail after a certain time period. This can lead to a total failure of the spacecraft.

In order to overcome the shortcomings of the prior art systems (e.g., louvers), the present invention utilizes a heat control device which is capable of efficiently and reliably working in many different extreme environmental conditions. The heat control device of the present invention is a substance used to coat the outer surface (e.g., heat radiation surfaces) of the spacecraft. The substance is a variable phase substance which preferably has a phase variation at room temperature. In one preferred embodiment, the substance comprises a perovskite Mn oxide of Mn-containing perovskite represented by $A_{1-x}B_xMnO_3$. In this embodiment, A is at least one of La, Pr, Nd and Sm rare earth ions, and B is at least one of Ca, Sr and Ba alkaline rare earth ions. Applicants have found that this substance exhibits emissivity characteristics of an insulator at a relatively high temperature and emissivity characteristics of a metal at a relatively low temperature. Thus, the substance exhibits a relatively low emissivity at the relatively low temperature and a relatively high emissivity at the relatively high temperature. The variable phase substance may also be oxide of Cr-containing corundum vanadium or a variable-phase substance comprising $(V_{1-x},Cr_x)_2O_3$.

Applicants further note that by using the substances disclosed herein, the phase transition temperature may be variable between the temperature ranges of 250°K and 350°K in accordance with the composition ratio of "x" of La and Sr. Also, it has been found that by using the substance of the present invention, reflectivity increases between 170°K to 380°K, with a sharp increase between 280°K and 300°K (e.g., phase transition temperature). Taking all of these properties into account, Applicants have found that the substances disclosed and claimed herein provide superior phase transition properties, which are capable of increasing the longevity of spacecraft by protecting such spacecraft from the extreme temperatures encountered in space.

Teeg et al. is directed to passive thermal control system for an enclosure such as a spacecraft. Teeg et al. describe an inner coating of a highly <u>reflective</u> metal such as aluminum, magnesium or silver and a second outer coating such as vanadium dioxide which has the <u>property of changing color</u> (i.e., transmissivity of incident radiant energy when heated to a transition temperature.) (Col. 3, lines 25-30 and 48-50.) At col. 4, lines 25-30 Teeg et al. describe that the transmissivity of the second coating is increased at increased temperatures and decreased at decreased temperatures. Thus, when the surface temperature of the body is above the transition temperature of the second coating, most of the incident radiant energy impinging upon the body is radiated back into space. Conversely, when the surface temperature of the body is below the transition temperature of the second coating, the transmissivity of the second coating allows the radiant energy to penetrate to the inner surface. (Col. 4, lines 50-60.) In this manner, the Teeg et al. system is capable of regulating the temperature of the body by use of a combination of a reflective surface and a substance which is capable of changing color.

On the other hand, Benson et al. is not concerned with the reflectivity of a specific substance nor is it directed to a substance which is capable of changing colors. Instead, Benson et al. is directed to the use of substances which have

certain emissivity properties. More particularly, Benson et al. disclose an ultra-thin insulation panel 10 with two sidewalls 12, 14 positioned in parallel and sealed at the edges by metal-to-metal welds 18 to enclose a space or vacuum chamber 15. (Col. 4, lines 40-45.) Low emissivity coatings 17, 19 are coated on the sidewalls 12, 14 (col. 5, lines 33-34) and glass-like spacers 16 are positioned at spaced intervals between the sidewalls 12, 14 to separate the sidewalls when the space of chamber 15 is evacuated (col. 4, lines 52-57). Variable emissivity coatings 170 may also be used by the Benson et al. apparatus (col. 7, lines 25-30). Benson et al. describe the use of vanadium oxide[1], titanium oxide (Ti_2O_3), nickel sulfide (NiS), and vanadium oxy fluoride ($VO_{2-x}F_x$) as well as electrochromic materials such as nickel hydroxide ($Ni(OH)_2$) or tungsten trioxide (WO_3). Benson et al. further describe the linear relation between the increase in gas pressure within the vacuum and the resulting heat transfer properties (col. 6, lines 10-30) as well as the effective elimination of thermal transfer across the vacuum insulation by use of the welds 18 (i.e., resulting in a thermal short) (col. 6, lines 50-55). It is also noted at col. 6, lines 57-62 that the dynamic or changeable compact vacuum insulation varies the resistance to heat flow between sidewalls 12, 14 by varying, for example, the emissivity of the coatings 17, 19. (Col. 6, lines 57-62.)

It is also submitted that the Benson reference definitely appears to misunderstand that vandium oxide (VO_2) has positive temperature dependency. VO_2 is conductive at high temperature and insulative at low temperature, i.e., VO_2 has a negative temperature variance, as is well known in the art. Attached hereto is a paper entitled, Pressure Dependence of the Resistance of VO_2, C. H. Neuman et al., Journal of Chemical Physics, Vol. 41, No. 6, 9/15/64 shoing the properties of VO_2. Also, the use of Ti_2O_3, NiS and VO_2-xFx also appears to have a negative

[1]Vanadium oxide can be doped to vary through a full range of emissivity, from about 0.05 to about 0.8, within about five degrees Celsius (5 °C.) temperature change.

temperature dependency. Keeping this in mind, the Benson embodiments appear to be incorrect. Thus, Benson cannot use VO_2 for a radiation control purpose. It is also noted emphatically that Al-xBxMnO_3 has a positive emissivity temperature dependency as shown by actual measurements in the attached paper, Development of Variable Emittance Radiator, SAE Rechnical Paper Series, 1999-01-2090 by Akira Okamoto et al.

At the outset, Applicants submit that none of the references teach or suggest a perovskite Mn oxide of Mn-containing perovskite represented by $A_{1-x}B_xMnO_3$, where A is at least one of La, Pr, Nd and Sm rare earth ions, and B is at least one of Ca, Sr and Ba alkaline rare earth ions. Applicants further submit that none of the references, even though ample opportunity was provided within these references, teach or suggest the substances of Cr-containing corundum vanadium or a variable-phase substance comprising $(V_{1-x},Cr_x)_2O_3$.

Second, Applicants note that the substances provided in the claimed invention are superior to the substances disclosed in the references of record. For example, the substance $A_{1-x}B_xMnO_3$ has superior performance properties; namely, $A_{1-x}B_xMnO_3$ has a large emissivity variation against temperature and a convenient transition temperature at room temperature. As important, the transition temperature may be modified by changing the composition of "x". The transitional temperature at room temperature is most beneficial to space applications since most satellite electric components have low operational temperature limits at -30°C to 0°C. On the other hand, vandium oxide has a transition temperature at 65°C, thus making vandium oxide inferior to the substances claimed herein.

Third, Applicants note that none of the references even remotely suggest or teach that the transition temperature of the substance $A_{1-x}B_xMnO_3$ depends upon a value of "x". This dependence advantageously allows a designer to modify the transition temperature of the substance of the claimed invention simply by changing "x" in the formula $A_{1-x}B_xMnO_3$. These features are simply not

taught in Teeg et al. or Benson et al., alone or in combination.

Fourth, Applicants submit that it would not have been obvious to one of ordinary skill in the art to use the substances disclosed in the Benson et al. reference with the Teeg et al. apparatus. Teeg et al. use two materials, a highly reflective metal and a metal which changes color. However, Teeg et al. do not contemplate the use of a substance having high emissivity properties and would thus not provide any motivation to one of ordinary skill in the art to interchange the substances of Benson et al. with Teeg et al.

Fifth, the Examiner noted that Benson et al. show the use of Vanadium Oxide which can be doped through a full range of emissivity (.05 to 0.8) within about 5 degrees Kelvin. The Examiner asserted that such a substance is superior to Applicants' claimed substance. Applicants note, however, that the such an emissivity is not applicable to the specific space applications of the present invention, and that the claimed substances are thus superior to the Benson et al. substance in use in the specific structure of the claimed invention. Specifically, the emissivity of the claimed substance increases between 170°K to 380°K, with a sharp increase between 280°K and 300°K (e.g., phase transition temperature). Australian. These are ideal properties for the specific structure and space application of the present invention.

Based on at least the foregoing differences, it is respectfully submitted that the claimed invention is distinguishable from the combination of the Teeg et al. reference and the Benson et al. reference. Thus, 1-4, 11-13, 16, 17 and 26-30 are in condition for allowance.

With regard to the rejection of claims 5, 6, 14, 15, 18 and 19, Applicants argue that these claims are dependent on distinguishable independent claims. Thus, these claims include the limitations of the respective independent claims and are also in condition for allowance. In any event, Applicants submit that there would be no motivation to combine the teachings of Amore with the combination of Teeg et al. and Benson et al. That is, Benson et al. would not require a coating

over the substance because the Benson et al. substance is located within a vacuum space, away from any light. Also, Teeg et al. uses a substance which is capable of changing color and thus transmissivity, and is thus not necessary to use a coating, as taught in Amore.

In view of the above remarks, Applicants submit that the claims of the present invention are distinguishable over the prior art of record. Applicants thus respectfully request that the entire application pass to issue. The Examiner is invited to contact the undersigned, if needed. Applicants make a conditional petition for extension of time, if required. Please charge any deficiencies in fees and credit any overpayment of fees to Attorney's Deposit Account No. 23-1951.

Respectfully submitted,

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